NOTES ON THE PROCESS OF FORMING CONTRACTILE ROOTS AND THE LOWERING OF THE FIRST BULBILS BY SEEDLINGS OF THE SOUTH AFRICAN OXALIS WHICH PRODUCE ENDOSPERMOUS SEEDS.

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I. A Short Summary of the Different Kinds of Contractile Roots in Oxalis Hitherto Recorded.

The first recorded examination of the behaviour of seedlings of Oxalis in forming their first bulb was published by Freidrich Hildebrand in 1884 in Lebensverhaltnisse der Oxalis-Arten, where he gave a description of this process in *Oxalis rubella* Jacq., a species which is synonymous with *O. hirta* L., or at least one of the many forms of that species. Later he observed similar action in seedlings of *O. Coppoleri* Tod., actually a form of *O. fabaefolia* Jacq. In both cases he was dealing with species which produce exendospermous seeds.

Hildebrand's observations were not very complete, but recently (1946) a very full account of the action of the slender contractile root in seedlings of *O. hirta* has been given by Miss A. J. Davey.(¹)

The seeds of the South African species of Oxalis are of two distinct kinds: (*a*) the small brown rugose, slow-germinating seeds containing endosperm; and (*b*) the rather larger soft green, quick-germinating seeds which are entirely without endosperm, and it was with seeds of the latter kind that the observations referred to above were made. Approximately 119 have exendospermous seeds and 82 endospermous.(²)

The highly important function of the contractile root and its action in lowering bulbs and bulbils has been described by several authors. The process is roughly speaking of three kinds: (*a*) the contractile action, generally more or less vertically, of a comparatively thick watery root, such as has been best described by Thoday(³) and Davey(⁴) in the case

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(¹) On the Seedling of *Oxalis hirta* L. by A. J. Davey, Annals of Botany, Vol. X, No. 39 (1946) pp. 237–256. It should be noted that *O. hirta* is included in § K. Angustatae, sub-section Sessilifoliatae, and not in § J. Crassulae as stated in the footnote on p. 237.

(²)The Genus Oxalis in South Africa, by T. M. Salter, Supp. Vol. I to the Journal of South African Botany, 1944, p. 26.

(³)The Contractile Roots of Oxalis incarnata, by D. Thoday, Ann. of Bot. XL, No. 159, July 1926.

(⁴)On the Mechanism of Root-contraction in Oxalis incarnata L. by D. Thoday and A. J. Davey, Ann. of Bot., Vol. XLVI, No. 184 (1932), pp. 993–1005.

of *O. incarnata*; (*b*) that of the slender thread-like contractile root in the seedling of *O. hirta* (Davey l.c.) and in the adult plant of *O. flava* L. (Davey l.c., pp. 250–251) and (*c*) the small contractile root which lowers the new bulb from aerial bulbils.(5)

Although the contractile action which takes place in the formation of the first bulb in species producing exendospermous seeds has only been observed in detail in *O. hirta*, seedlings of 8 other species with similar seeds were raised with the object of ascertaining the nature of the first leaf.(6) From admittedly superficial observation of the development of these seedlings I do not think it is unreasonable to suppose that the first bulb formation is on similar lines in all the species producing these seeds.

II. THE FORMATION OF THE BULBS AND THE ACTION OF THE CONTRACTILE ROOT IN SEEDLINGS OF SOUTH AFRICAN OXALIS PRODUCING ENDOSPERMOUS SEEDS.

As far as I am aware no previous observations have been published as regards the bulb formation in seedlings of the South African Oxalis producing endospermous seeds. Here, although a contractile root comes into play, the process is different. It is true that the action has only been observed in two species, *O. tragopoda* Salter and *O. dentata* Jacq. and the observation has only been superficial.

In all the bulb-lowering processes referred to in Part I, where contractile roots come into play, there is always a compensating intercalary elongation of some organ of the plant, in the seedlings, the petiole and in the adult plants the underground stem, so that the aerial part of the plant is not affected. In this case, however, there is no intercalary elongation. Sessile bulbils, similar to those of the adult plants, but smaller, are formed on the underground stem and when the contractile root below them starts its action, the whole plant begins to sink gradually into the ground.

OXALIS TRAGOPODA Salter

Oxalis tragopoda of the § Cernuae, sub-section Stellatae, a species with endospermous seeds, fairly plentiful in the neighbourhood of Grahamstown, is being grown in the National Botanic Gardens at Kirstenbosch. In June 1949, seeds of this species, among others, were sent to the Department of Genetics at Cambridge University. I was surprised to hear that these seeds had produced flowering plants, under glass, by

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(5)Notes on the Aerial Bulbils in Oxalis laburnifolia Jacq.; Salter in Journal of S.A. Bot.. XIV (1948), pp. 15–18.

(6)The Genus Oxalis in S. Africa (1944), p. 28.

November, i.e. about 4½ months after gathering, for, judging from the process of bulb formation hitherto observed in species with exendospermous seeds, it seemed impossible that mature bulbs could have been formed in such a short time and it appeared unlikely that even the climatic change to the northern hemisphere could have had so much influence.

In June 1950, some seeds were collected and sown at Kirstenbosch, but only three germinated after 7 weeks. One seedling actually flowered in November before forming an adult bulb, producing, as it were, a second crop in one year. At this time it was observed that the plants were gradually sinking into the ground. When the underground system was examined in December it was found that a cluster of small bulbils had developed just below the leaves and that a fleshy contractile root, similar in appearance to those of the adult plants of *O. incarnata*, described by Thoday and Davey (see Part I) had been formed. This root was partially contracted and was in the process of drawing the whole plant into the ground taking the bulbils with it and so giving them a greater depth for normal growth in the next year, after the vegetative parts, which are annual in the South African Oxalis, had died away.

OXALIS DENTATA Jacq.

Seeds of *O. dentata* of the § Cernuae, sub-section Lividae, a common species in the Cape Peninsula, were collected early in June 1951, and sown at once in a glass-house at Kirstenbosch and they began to germinate freely after 13 days. The seedlings appeared to be much like adult plants, though smaller, except that many of them did not produce any aerial stem. They produced 2 to 5 normal leaves with petioles 2 to 4 cm. long. In October there was appreciably less of the petioles showing above ground and by the middle of November only about 1 cm., or less, was visible. At this stage one of the two tins containing them was opened up and they were found to be in the state shown in Fig. 1—AAA. The seeds had germinated more freely than had been expected and the numerous fibrous roots, often up to 10 cm. long, were so matted together that it was necessary to wash the plants out of the soil. The contractile roots, which appeared to be similar to those of *O. incarnata*, were not fully contracted. The plants had each produced 1—3 (commonly 2) sessile bulbils, similar to those of the adult plant, the largest about 1 cm. long, some on the short underground stem above the crown of the contractile root and some in the axils of the leaves, but they were never visible above ground. They were being drawn down into the soil with

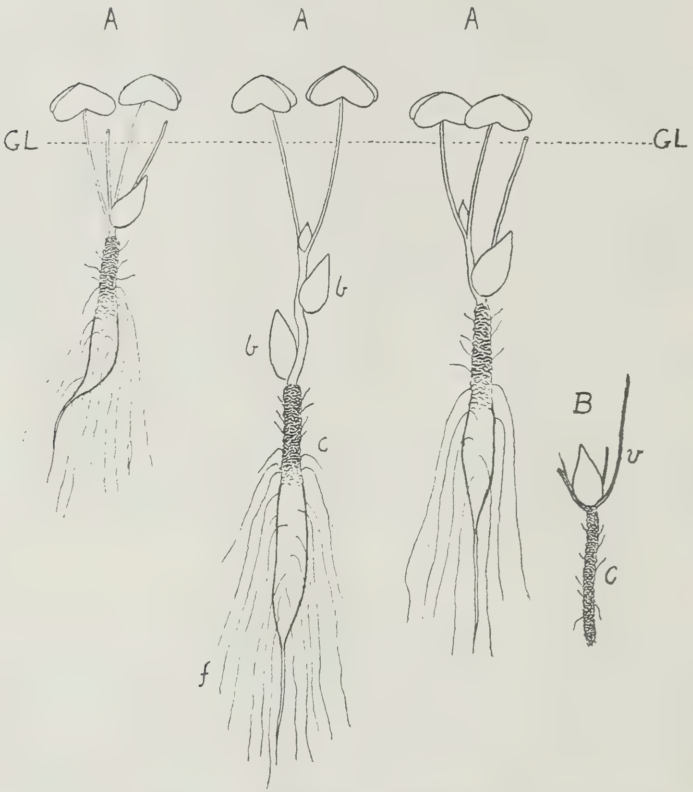

Fig. 1.—AAA. Seedlings of *Oxalis dentata* Jacq. five months after germination; G.L. ground level; b, bulbils; c, contractile root; f, fibrous roots (reduced in number and length). B, a bulbil at its final depth (4—7 cm.) 7½ months after germination, with (v) the dead remains of the vegetative parts and (c) completely exhausted contractile root. Approximately natural size.

the rest of the plant which dies away when its bulb-producing function is completed. By the middle of December all traces of the seedlings had disappeared underground. Late in January 1952, when it was estimated that the contractile process would be complete, the second tin was opened up. Unfortunately, owing to a change in the Gardens staff, the tin had been watered freely and this had probably hastened the decomposition of the contractile roots and vegetative parts which had broken away from the bulbils and were very difficult to find. The bulbils, which had scarcely increased in size, were found at varying depths, a few near the surface appeared to have broken away from the seedlings in their descent, but the majority were found at a depth of 4 to 7 cm. In several the completely exhausted contractile root, or at least part of it, was found still adhering and one (Fig. 1—B) was extracted with the bulbil and contractile root still attached to the dead remains of the vegetative parts.

Although the final stage would have been seen more clearly if the tin had been opened up earlier, the main object was to ascertain the size the bulbils had attained and the depth to which they descend in the first year.

In the adult stage the bulbs of *O. dentata* are usually found at a depth of 8 to 12 cm. and this species has the peculiar and perhaps unique habit of developing a long *horizontal* contractile root which draws the new bulb sometimes as much as 1 ft. from the parent plant and adult bulbs are consequently always found lying on their sides, as shown on Plate II (i), opposite page 82 in The Genus Oxalis in South Africa. The contractile action in the case of the seedlings is, of course, vertical.

The bulbils as finally produced by the seedlings, though now brown and showing the characteristic longitudinal grooves of the species, are obviously immature and it seems probable that a second and possibly a third annual lowering process will be necessary before adult flowering bulbs are developed. The bulbils formed by seedlings of this species raised at Cambridge showed no sign of flowering in the second year.

Conclusions

The bulb formation in *O. tragopoda* and *O. dentata* described above suggests that a similar process comes into play in all the species bearing endospermous seeds. Unfortunately the seeds of many of these species, particularly those with solitary flowers, are by no means easy to collect and many of them do not germinate freely. Seeds of *O. pes caprae* L., *O. purpurata* L. and *O. lanata* L.f., sent to Cambridge in 1949, failed to germinate at all.

I have, however, placed the foregoing facts on record in the hope that some younger observer, who may have better facilities than myself, may be able to inquire more deeply into the subject.

It would be advantageous to sow the seeds in as many receptacles as possible in order to allow of at least monthly inspection of the underground development. A friable soil, mixed with plenty of sand, would probably be found most suitable and the admixture of any humus or sifted compost should be avoided.

In all probability the species known to have seeds with a thin layer of endosperm, and in which the embryo is green, would be the best for trial. Of these, *O. Bowiei* Lindl. and *O. imbricata* E. & Z. suggest themselves, since they have been proved to germinate quickly and, although they do not occur in the Cape Peninsula, are by no means rare.

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